Toxicity of Some Organophosphates and Carbamates Against Epilachna vigintioctopunctata F.

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The higher concentration, the longer exposure period and the earlier stage being fumigated were, the less emergence was always.

When the product of concentration and exposure period was a constant, the higher concentration was or the shorter exposure period was, the more emergence weevils was at all times.

Toxicity of Some Organophosphates and Carbamates Against *Epilachna vigintioctopunctata*
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16. ニジュウヤホシテントウに対する数種有機リン剤およびカーバメート剤の殺虫力

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シャーレ内の殺虫剤被膜にニジュウヤホシテントウの終令幼虫および成虫を接触させ，殺虫力の比較を行なった．幼虫の LC_{50} 値では carbayl, fenitrothion, monocrotophos および phosphamidon は dimethoate よりそれぞれ 3.0, 1.8, 1.6 および 1.3 倍殺虫力が強かった．成虫に対しては carbaryl, fenitrothion, phosphamidon, monocrotophos および malathion は dimethoate よりも 20.4, 14.3, 8.6, 5.4 および 2.5 倍殺虫力が強かった．Fenthion の LC_{50} と LC_{90} 値および dimethoate の LC_{90} 値以外ではすべての殺虫剤は幼虫よりも成虫に殺虫力が強かった．

Epilachna vigintioctopunctata F. and some other species are very serious pests, causing immense damage to brinjal (*Solanum melongena* L.), potato (*S. tuberosum*), Dhatura (*Datura stramanium*), nightshade (*S. nigrum*) and other solanceous plants in India and abroad. The other species of *Epilachna* are reported to feed on several bean varieties (Anderson, 1955)[1], wheat, maize, oats, barley (Walker, 1957[2]; Smithers, 1957[3]), peppers (*Capsicum* sp.) (Peterson, 1956[4]), cucurbits (Melamed, 1956[5]). Koyama (1950)[6] reported 29 spp. of plants under 7 different families as food plants of *E. vigintioctomacultata* Motschulsky. According to Pukinskaya (1965)[7] *E. vigintioctomaculata* is an important pest of potato in Soviet Far East, that caused 50-60 per cent damage in Sakhalin in some years and 50-100 per cent in Maritime Province in 1960. Rehman (1940)[8] mentioned that the grubs confine to the lower surface and the adults to the upper surface of the leaves of brinjal and other solanaceous plants. The adult beetles are reported to be more injurious than the grubs and are also susceptible to various insecticides (Shi *et al.*, 1960[9] and Jotwani *et al.*, 1962[10]).

Materials and Method

The eggs of *E. vigintioctopunctata* were collected from the brinjal and potato fields and were kept in the laboratory for mass culture at the temperature ranging 27±2°C and relative humidity 70±10 per cent. The grubs on hatching were separated and reared on brinjal leaves provided with water soaked cotton at their petioles, to maintain freshness and turgidity of the leaves. The grubs in last instar (16-17 days old measuring about 7×3 mm) and adults (3-4 days old) were used to assess the relative toxicity of six organophosphorus and one carbamate insecticides (Table 1), of commercial grades.

One per cent stock solution of each insecticide was prepared by dissolving them in acetone except carbaryl which was dissolved in methanol. The stock solutions were kept in the refrigerator and were utilized for preparing various concentrations of each insecticide to find out median lethal concentrations and ultimately to study the relative efficacy.

One cc of individual concentration was taken in each piece of petridishes (10 cm dia.) and rotated quickly to make a uniform film on the walls and the bottom of the petridishes. Ten test

Table 1. Showing relative toxicity of seven insecticides to the grubs of *E. vigintioctopunctata*

S. No.	Insecticide (Formulation used)	No. of doses	Chi^2	Slope S.E.	Intercept	LC_{50} (LC_{90})	Upper limit	Lower limit	Relative toxicity	Relative* toxicity with *p,p'*-DDT
1.	Carbaryl (Sevin 85 S. P.)	7	11.07	1.723 ±.274	1.592	0.0095 (0.0526)	0.0126 (0.0959)	0.0063 (0.0368)	3.00 (2.02)	22.12
2.	Fenitrothion (Accothion 100 E.)	7	11.07	1.354 ±2.06	2.004	0.0163 (0.1438)	0.0224 (0.3242)	0.0107 (0.0890)	1.75 (0.74)	12.90
3.	Monocrotophos (Azodrin 60 EC)	5	2.81	2.141 ±.381	0.136	0.0177 (0.0702)	0.0231 (0.1249)	0.0120 (0.0510)	1.61 (1.52)	11.87
4.	Phosphamidon (Dimecron 100 EC)	6	9.49	1.466 ±.285	1.566	0.0220 (0.1644)	0.0309 (0.4702)	0.0134 (0.0977)	1.30 (0.65)	9.55
5.	Dimethoate (Rogor 30 EC)	6	9.49	2.241 ±.359	−0.504	0.0285 (0.1064)	0.0360 (0.1794)	0.0210 (0.0781)	1.00 (1.00)	7.37
6.	Fenthion (Lebaycid 1000 E)	6	9.49	1.807 ±.304	0.309	0.0394 (0.2019)	0.0516 (0.4528)	0.0292 (0.1300)	0.72 (0.53)	5.33
7.	Malathion (Malathion 50 EC)	7	11.07	1.815 ±.285	0.269	0.0403 (0.2048)	0.0514 (0.4069)	0.0301 (0.1381)	0.71 (0.52)	5.21

$$\text{Relative toxicity} = \frac{\text{LC dimethoate}}{\text{LC candidate}}$$

* In comparison to LC_{50} value of *p, p'*-DDT (0.21010) obtained by Shi *et al.*
Figures in parenthesis denote LC_{90}.

insects were released to assess the toxicity and the mortality counts were recorded 12 hours after released. Three such replications were maintained for each of the 5-8 concentrations of different insecticides. The mortalities, where observed in control taken with each insecticide, were corrected by Abott's (1925)[11] formula by the computer. The mortality counts of the grubs and beetles were made under dissecting binocular microscope.

The data so obtained were analysed at the Computer Centre, Institute of Agricultural Research Statistics, New Delhi using the programme of Daum and Killcreas (1966)[12] for Probit analysis (Finney, 1952)[13]. Relative toxicity of various insecticides, against both the grubs and adults, has been calculated by taking LC_{50} and LC_{90} values of dimethoate as unit.

The LC_{50} and LC_{90} values of each insecticide together with their upper and lower limits (occassionally referred to as fiducial limits by other workers) are presented in Tables 1 and 2 with other details.

Results and Discussion

(i) *Against last instar grubs*:

The order of toxicity at LC_{50} of different insecticides against the grubs is carbaryl > fenitrothion > monocrotophos > phosphamidon > dimethoate > fenthion > malathion. From this it is clear that first four insecticides are more toxic than dimethoate being 3.0, 1.8, 1.6 and 1.3 times respectively and the last two are less toxic being 0.72 and 0.71 times as toxic as dimethoate. But at the level of LC_{90} carbaryl and monocrotophos only are found to be more toxic being about 2.0 and 1.5 times as toxic as dimethoate. Rest of the four insecticides (fenitrothion, phosphamidon, fenthion and malathion) are less toxic being about 0.74 to 0.52 times as toxic as dimethoate (Table 1).

(ii) *Against the adults*:

Out of the seven insecticides tested five viz. carbaryl, fenitrothion, phosphamidon, monocrotophos and malathion appear to be more toxic at their LC_{50} values being 21.2, 14.5, 8.6, 5.4 and 2.6 times as toxic as dimethoate, respectively. Whereas fenthion appears to be less toxic being 0.34 times as toxic as dimethoate. The order of toxicity among themselves is carbaryl > fenitrothion > phosphamidon > moncrotophos > malathion > dimethoate > fenthion. At the LC_{90} values phosphamidon shifts its position and the order of

Table 2. Showing relative toxicity of seven insecticides to the adults of *E. vigintioctopunctata*

S. No.	Insecticide	No. of doses	Chi²	Slope S. E.	Intercept	LC_{50} (LC_{90})	Upper limit	Lower limit	Relative toxicity	Relative toxicity with *p, p'*-DDT*
1.	Carbaryl	7	11.07	3.904 ±.491	0.590	0.0013 (0.0029)	0.0015 (0.0037)	0.0012 (0.0024)	21.15 (41.07)	13.92
2.	Fenitrothion	6	9.49	2.112 ±.321	2.289	0.0019 (0.0078)	0.0025 (0.0123)	0.0013 (0.0058)	14.47 (15.27)	9.53
3.	Phosphamidon	8	12.59 £	1.361 ±.228	2.950	0.0032 (0.0280)	0.0044 (0.0675)	0.0032 (0.0173)	8.59 (4.25)	5.66
4.	Monocrotophos	6	9.49	2.683 ±.397	0.423	0.0051 (0.0152)	0.0061 (0.0235)	0.0041 (0.0117)	5.39 (7.84)	3.55
5.	Malathion	6	9.49	3.941 ±.559	−3.011	0.0108 (0.0228)	0.0123 (0.0307)	0.0093 (0.0189)	2.55 (5.22)	1.68
6.	Dimethoate	7	11.07	2.010 ±.276	0.096	0.0275 (0.1191)	0.0345 (0.1890)	0.0204 (0.0883)	1.00 (1.00)	0.66
7.	Fenthion	6	9.49	2.636 ±.535	−2.677	0.0817 (0.2504)	0.0975 (0.5290)	0.0676 (0.1782)	0.34 (0.48)	0.22

$$\text{Relative toxicity} = \frac{\text{LC dimethoate}}{\text{LC candidate}}$$

* In comparison to LC_{50} value of *p, p'*-DDT (0.0181) obtained by Jotwani *et al.*

£ Data heterogenous.

Figures in parenthesis denote LC_{90} values.

toxicity changes as carbaryl > fenitrothion > monocrotophos>malathion>phosphamidon>dimethoate>fenthion. Though all the five insecticides which were more toxic than dimethoate at LC_{50} value are still more toxic and fenthion alone continues to exhibit lower toxicity than that of dimethoate. The change in the relative toxicity can easily be ascertained from the values of LC_{50} and LC_{90} (Table 3).

Very few insecticides have so far been screened against the grubs and adults of *E. vigintioctopunctata* in India by Shi *et al.*[9] and Jotwani *et al.*[10]. They screened the synthetic chemicals of three groups viz. chlorinated hydrocarbons, organophosphates and carbamates. In the present experiment only those insecticides were included, which are comparatively safer to use on vegetables, either because of their low toxicities to warm blooded animals or for the short residual toxicity of these insecticides permitting the consumption of vegetables few days after the treatment. Amongst the insecticides tested in the present investigation only the malathion and carbaryl have been tested by earlier workers

Table 3. Relative toxicities of seven insecticides against grubs and adults of *E. vigintioctopunctata* F.

S. No.	Insecticides	At LC_{50}	At LC_{90}
1.	Fenitrothion	8.58	18.44
2.	Carbaryl	7.31	18.14
3.	Phosphamidon	6.88	5.87
4.	Malathion	3.73	8.98
5.	Monocrotophos	3.47	4.62
6.	Dimethoate	1.04	0.89
7.	Fenthion	0.48	0.81

$$\text{Relative toxicity} = \frac{\text{Value for grubs}}{\text{Value for adults}}$$

(Shi *et al.*[9]; Jotwani *et al.*, 1962[10]) and the rest are not yet reported. Shi *et al.*[9] reported 0.3388 as the LC_{50} value for malathion against the grubs.

Jotwani *et al.*[10] later tested two insecticides viz carbaryl and *p, p'*-DDT against the grubs and nine insecticides against the adults collected from the field and pre-conditioned for 24 hours in the laboratory. The age of grubs was not mentioned but only the measurement was reported as 6.0±

1.0 mm. They stated carbaryl as highly toxic being 138.7 times as toxic as *p, p'*-DDT. Against the adults parathion, phosdrin and carbaryl were more toxic than *p, p'*-DDT being about 86.0, 58.6 and 25.7 times.

The LC_{50} values of DDT for grubs 0.21010 and 0.23790 as reported by Shi *et al.*[9] and Jotwani *et al.*[10] respectively differ. The LC_{50} values of malathion for grubs recorded by Shi *et al.*[9] and for beetles obtained by Jotwani *et al.*[10] were 0.3388 and 0.01843 in comparison to 0.0403 and 0.0108 obtained in the present study respectively. The present observation is closer to the value reported for the adults by earlier workers. But wide variations are found in LC_{50} value for grubs which is about eight times more than the value obtained in the present study. The most vital probable reason for such wide variation appears to be the method of application of insecticides. The higher value reported by Shi *et al.*[9] might be due to spraying of liquid directly over the insects and transferring them into clean jars provided with untreated leaves. Though they recorded observations after 48 hours and used insects of smaller size. Whereas in the present study observations were recorded after 12 hours using the grubs of bigger size. This indicates that the method of insecticide application adopted in the present study is superior than that used by Shi *et al.*[9].

The carbaryl which was tested by Jotwani *et al.*[10] do not conform with the present observations and aforesaid reasons, where the LC_{50} values for carbaryl were 0.001715 and 0.000703 for grubs and adults respectively. Comparatively higher strength i.e. 0.0095 and 0.0013 obtained in the present study indicates that contact film method with carbaryl is not so effective for this insect. The reason might be attributed to slow entry of toxicant through tarsal ends of this insect during the period by the contact film method. Hayes and Liu (1947)[15] reported on the basis of morphology of tarsal organs that the entry of insecticides through the feet is much more rapid in *Musca* than in *Epilachna* or *Blatella*, which corroborates the present findings. Further, the observation period which also plays an important role for high and low LC_{50} value must have been helpful in obtaining desired kill at comparatively low concentrations in the experiments of Jotwani *et al.*[10].

Rest of the five insecticides viz. phosphamidon, fenitrothion, dimethoate, monocrotophos and fenthion have not been screened earlier against this pest. The tests have revealed that all of them are more toxic than malathion but less toxic than carbaryl to both the stages of *E. vigintioctopunctata* with few exceptions with the adults of the pest.

If the present findings are compared with the LC_{50} value of *p, p'*-DDT (0.21010) obtained by Shi *et al.*[9] dimethoate appears to be 7.37 times more toxic than *p, p'*-DDT for grubs. The relative toxicity with other insecticides are given in Table 1. Haynes *et al.*[14] reported median lethal concentration of Sevin as 0.8 mg/100 m*l* solvents for the larvae of *E. varivestis* when the detached bean leaves were dipped in the insecticide and provided to *Epilachna* larvae.

(iii) *Comparative toxicity*:

To judge the comparative toxicity between larval and adult stages of *E. vigintioctopunctata* the LC_{50} or LC_{90} values of individual insecticide for larval stages have been considered as unit and relative toxicity calculated for adults has been presented in Table 3. On the basis of LC_{50} values fenitrothion, carbaryl and phosphamidon appear to be highly toxic to the adult stage being about 8.6, 7.3 and 6.9 times as toxic as to the last instar grubs. In general almost all the insecticides appear to be more toxic to the adult stage except fenthion which shows lower toxicity being 0.48 times as toxic as for the grubs. The views of Jotwani *et al.*[10] that the LC_{50} values for grubs were much higher than for the adults are supported by the present findings, in addition similar trend has been found at LC_{90} with most of the insecticides tested excepting fenthion and dimethoate.

At LC_{50} values carbaryl appears to be the most toxic insecticide against the grubs and adults. Similarly fenitrothion occupies second place. Monocrotophos appears third in order of toxicity against grubs while phosphamidon against the beetles (Tables 1 and 2). At LC_{90} values as well, the carbaryl showed highest toxicity both against

grubs and adults occupying first position. Monocrotophos appears to be next to carbaryl aginst the grubs while fenitrothion against the adults. This clearly denotes the specificity of carbaryl for both grubs and adults of *E. vigintioctopunctata* amongst the insecticides tested.

On the basis of LC_{90} values of individual insecticide against both grubs and beetles of *E. vigntioctopunctata* fenitrothion appears to be highly toxic against beetles being about 18.4 times followed by carbaryl being 18.1 times as toxic as to the grubs. Rest of the five insecticides in descending order are malathion, phosphamidon, monocrotophos, dimethoate and fenthion respectively being about 9.0, 5.9, 4.6, 0.9 and 0.8 times as toxic as to the grubs. Dimethoate and fenthion thus show lower toxicity towards the beetles in comparison to the grubs at LC_{90} values.

Summary

Relative toxicity of 7 insecticides viz. phosphamidon, fenitrothion, dimethoate, monocrotophos, fenthion, and carbaryl were determined against the last instar grubs and the adults of *Epilachna vigintioctopunctata* F. by contact with the insecticidal films in petridishes.

Carbaryl, fenitrothion, monocrotophos and phosphamidon were, respectively about 3.0, 1.8, 1.6 and 1.3 times as toxic as dimethoate against the grubs and the carbaryl, fenitrothion, phosphamidon, monocrotophos and malathion were about 21.1, 14.5, 8.6, 5.4 and 2.6 times as toxic as dimethoate against the adults at their LC_{50} values. All the insecticides were found to be more toxic to the adults except fenthion at LC_{50} and fenthion and dimethoate at their LC_{90} values.

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